



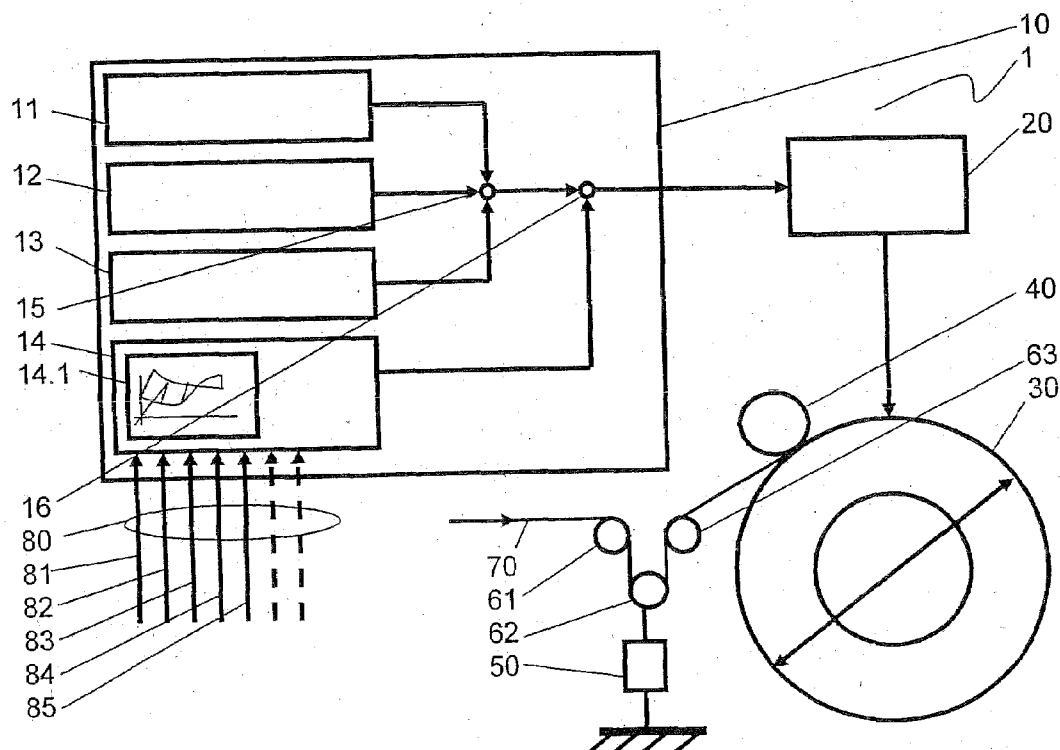
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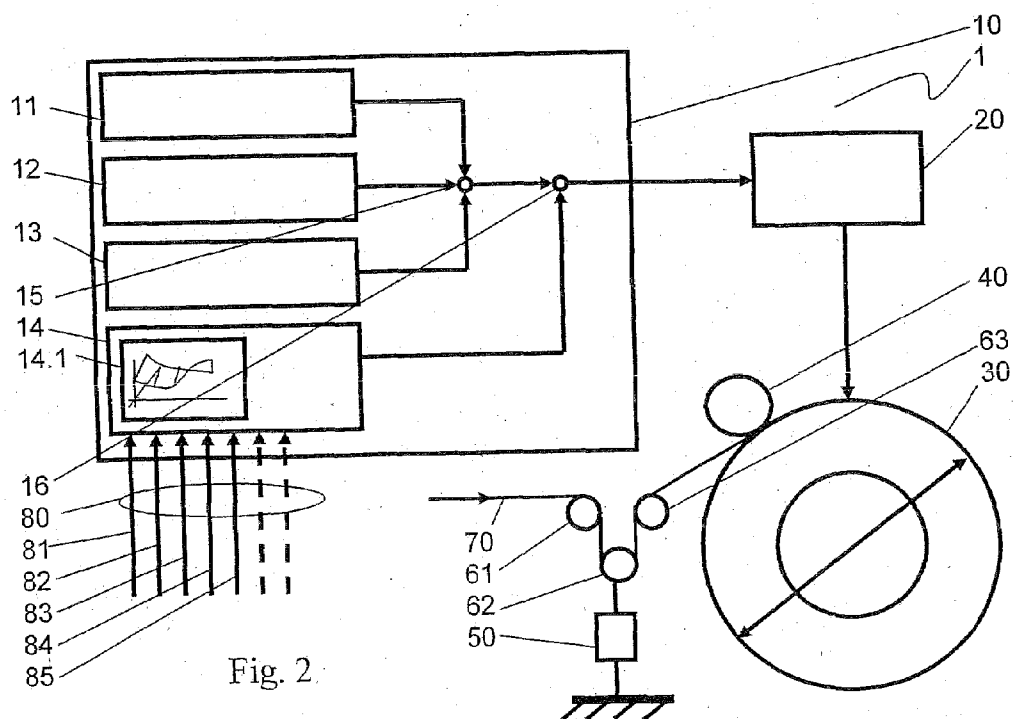
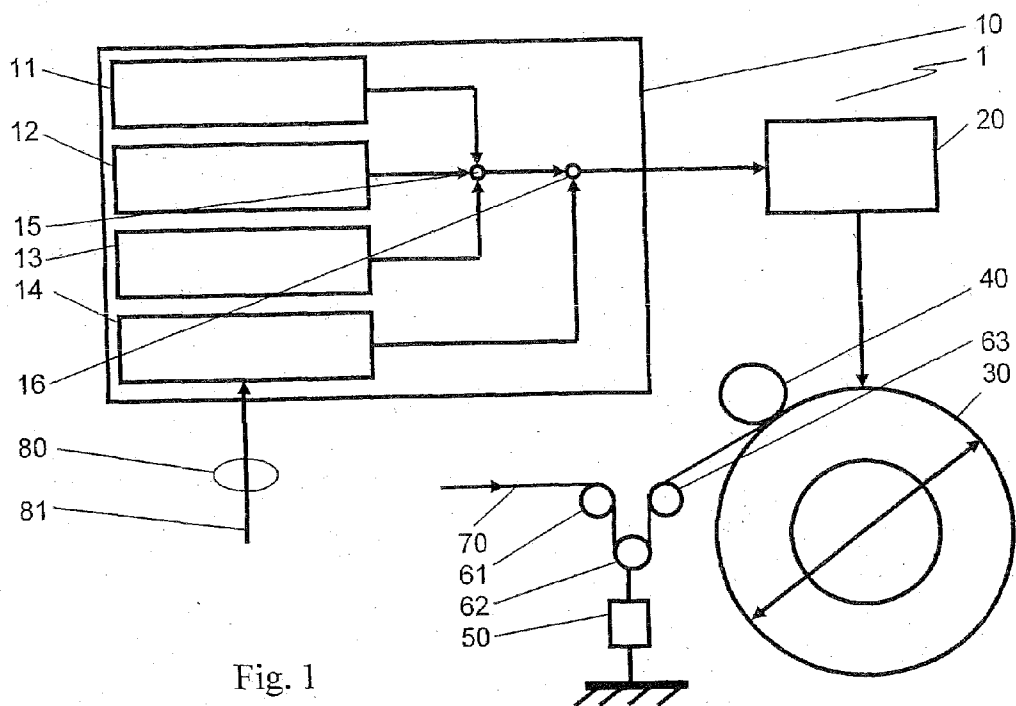
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Mueller et al.(10) **Pub. No.: US 2008/0197228 A1**(43) **Pub. Date: Aug. 21, 2008**(54) **METHOD AND APPARATUS FOR FRICTION
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Publication Classification(51) **Int. Cl.***B65H 23/195* (2006.01)*B65H 23/198* (2006.01)(52) **U.S. CL.** **242/410; 242/419.9**(57) **ABSTRACT**

For friction compensation in a winding machine, with which a material is wound onto a winding drum, and the winding drum is driven by a winding drive which is triggered by a control/regulating device, and in the control/regulating device a driving torque of the winding drive is specified, in a friction compensation unit, as an input-side process parameter, a winding speed of the winding drum is taken into account, in order to compensate for the frictional moment, and at least one additional process parameter is taken into account. An apparatus for friction compensation in a winding machine, with which a material is windable onto a winding drum, and the winding drum is driven by a winding drive which is triggerable by a control/regulating device, has a tensile stress regulator and a diameter calculation unit and/or a friction compensation unit for linearizing the tensile stress regulator located in the control/regulating device, and in the friction compensation unit, a winding speed of the winding drum is imposed, in which to compensate for the frictional moment in the friction compensation unit, at least one additional process parameter is imposed as an input-side process parameter.





METHOD AND APPARATUS FOR FRICTION COMPENSATION

CROSS-REFERENCE TO A RELATED APPLICATION

[0001] The invention described and claimed hereinbelow is also described in German Patent Application DE 10 2007 007 988.7 filed on Feb. 17, 2007. This German Patent Application, whose subject matter is incorporated here by reference, provides the basis for a claim of priority of invention under 35 U.S.C. 119(a)-(d).

BACKGROUND OF THE INVENTION

[0002] The invention relates to a method for friction compensation in a winding machine, with which a material is wound onto a winding drum, and the winding drum is driven by a winding drive which is triggered by a control/regulating device, and in the control/regulating device a driving torque of the winding drive is specified, and in a friction compensation unit, as an input-side process parameter, a winding speed of the winding drum is taken into account, in which to compensate for the frictional moment, at least one additional process parameter is taken into account.

[0003] The invention furthermore relates to an apparatus for friction compensation in a winding machine, with which a material is windable onto a winding drum, and the winding drum is driven by a winding drive which is triggerable by a control/regulating device, and both a tensile stress regulator and a diameter calculation unit and/or a friction compensation unit for linearizing the tensile stress regulator are located in the control/regulating device, and in the friction compensation unit, a winding speed of the winding drum is imposed, in which to compensate for the frictional moment in the friction compensation unit, at least one additional process parameter is imposed as an input-side process parameter.

[0004] Winding machines for winding up weblike materials, such as fiber materials, paper, films and foils, fabrics, thin metal sheets, etc., or wirelike or yarnlike materials, are widely known in the literature. A definitive feature of such machines is exact regulation of the tensile stress in the winding operation, to avoid uneven or defective results of the winding. A series of documents therefore has to do with the motor regulation for the drives in such machines.

[0005] For instance, in German Patent Disclosure DE-OS 39 19 162 A1, a regulating device for winding machine is described with which the tensile stress at a product extending from a delivery roller to a takeup spindle is regulated. The regulating device includes an rpm ratio control unit with a fast response speed for precise control of the various rotary speeds of a supply motor for driving the delivery roller and of a winding motor for driving the takeup spindle during braking of the winding machine. It can thus be attained that the product is kept under tension that is essentially equal to a predetermined tensile stress when the mode of operation remains the same. With the regulating device, the time required for stopping the winding machine is reduced to the very minimum.

[0006] From DE-OS 103 42 020 A1, a winding machine for winding a web of material, in particular a web of fiber material, with an air squeezing roller that can be pressed against a drum (takeup roller) is known in which the rpm and/or torque of the air squeezing roller can be regulated as a function of an instantaneous tension on the web of material.

[0007] As a rule, winding machines are made with torque- or current-limited rpm regulation. The value for limiting the torque or current is composed of a plurality of components. These components are the torque component for the tensile stress, the torque component for the acceleration, and the frictional moment.

[0008] The control/regulating devices of the winding machines, which are also known as winding computers, therefore comprise a plurality of functional elements, which calculate the various torque components for the drive and trigger the winding drive accordingly.

[0009] Besides a tensile stress regulator, which represents the primary component for the actual closed control loop, modern winding computers as a rule also have a diameter calculation unit, or acceleration compensation unit, as well as a friction compensation unit, which serve to linearize the controlled system for the actual tensile stress regulator of the winding computer, to enable regulation that is as independent of interference variables as possible. The individual components in the winding computer are subjected on the input side to various process parameters, which in part are detected via suitable sensors in the winding machine or are calculated by means of models.

[0010] With regard to friction compensation, in the prior art only relatively simple models are taken into account. It is currently usual for only the rpm of the winding shaft or the winding speed is used as the process parameter for ascertaining a friction compensation value. Moreover, there are often no aids whatever for adjusting the required parameter values for compensation. Until now, only systems in which a characteristic curve, formed from the rpm of the winding axle and the frictional moment, can be defined by a few interpolation points are known. Such a system is known for instance in conjunction with the control/regulating devices for winding machines of the REXROTH SYNAX 200 type, in which a frictional moment at a standstill, a minimal frictional moment at a defined rpm, and a maximum frictional moment at a limit speed value are specified in the form of interpolation points for a simple characteristic curve.

[0011] It is disadvantageous in this respect that essential frictional effects cannot be taken into account in the regulation. For instance, depending on the mass of the winding, the bearing friction and gear losses are variably high. The contact pressure of an optimal contact pressure roller are not taken into account in modern friction compensation units, either. Other non-constant friction effects result for instance from bearing-dependent friction, of the kind that can occur in certain gear configurations, and from temperature-dependent friction.

[0012] Because of all these friction components that are not taken into account, the controlled system becomes nonlinear. As a consequence, the control algorithm cannot be set optimally, or the effort and expense of setting and testing the set parameters become quite high. Moreover, the interference performance of the overall system is limited as a result.

SUMMARY OF THE INVENTION

[0013] It is therefore the object of the invention to furnish a method which makes it possible to take the friction components in winding operations into account better and also enables better ascertainment of the compensation parameters. A further object of the invention is to furnish a corresponding apparatus.

[0014] The object pertaining to the method is attained in that to compensate for the frictional moment, at least one additional process parameter is taken into account. As a result, the various friction compensation components can be better taken into account in the specification of the driving torque, resulting in markedly improved regulation.

[0015] If by means of a tensile stress regulator, a desired tensile force is calibrated with a measured actual tensile force, then deviations from the specification can be detected directly, and the driving torque can be adapted accordingly.

[0016] If setting the tensile force is effected by means of a control part, then in this case a measuring device for the actual tensile stress value can be dispensed with, which makes a simplified construction possible that is correspondingly less expensive.

[0017] In a preferred variant embodiment, it is provided that in the control/regulating device, the driving torque of the winding drive is specified with a diameter calculation unit and/or the friction compensation unit. A more-precise specification of the driving torque can thus be calculated.

[0018] A further preferred variant method provides that in the control/regulating device, the driving torque of the winding drive is specified with an acceleration compensation unit. Additional dynamic effects can thus be taken into account in the specification of the driving torque.

[0019] If for compensation for the frictional moment, a winding mass and/or a temperature and/or a roller contact pressure and/or an actual motor angle or winding angle value is used as the additional input-side process parameter, then winding mass-dependent friction, contact pressure-dependent friction, location-dependent friction, and temperature-dependent friction effects can all be taken into account. Depending on the mass of the winding, for instance, the bearing friction or the gear losses may differ. Moreover, because of the contact pressure of an optional contact pressure roller, a different driving torque may be required. Location-dependent friction can occur for instance from meshing gear wheels in which the friction is not constant over the circumference. This is the case particularly with a coarse pinion pitch (that is, a low number of gear wheel teeth). This friction can occur on the motor side, the load side (winding), or anywhere within a gear between the motor and the load. Temperature-dependent friction can occur for instance when toothed belts are used as a step-up member between the motor and the winding. At relatively high load, the friction of this toothed belt is in particular temperature-dependent, since the belt heats up, which in turn can result in altered friction. Heating up as a rule causes lengthening of the toothed belt, which can cause reduced friction, since upon lengthening, the tension of the toothed belt decreases. These effects can now be taken into account markedly better, with the method of the invention.

[0020] A variant method of the invention provides that the individual process parameters used for compensating for the frictional moment are evaluated independently of one another and additively linked to a total drive compensation. This has the advantage that in addition to the rpm-dependent friction compensation value at present, still additional friction compensation values, such as a winding mass-dependent friction compensation value, can be added together and treated independently of one another, which offers advantages in terms of a simplified algorithm.

[0021] However, a variant method also provides that, of the individual process parameters used to compensate for the

frictional moment, at least two are linked to one another and from that a compensation value is ascertained. This is advantageous particularly with a view to complex, mutually dependent relationships for ascertaining the friction compensation.

[0022] It is especially advantageous if compensation parameters for the individual process parameters for determining the compensation value are prepared in the form of one or more characteristic curve graphs or performance graphs, and the compensation value for the frictional moment is ascertained from the performance graphs either directly or by interpolation between interpolation points. This makes it possible to take especially complicated relationships into account, relationships that cannot readily be represented by means of functions.

[0023] A further variant method of the invention provides that the compensation parameters for the individual process parameters are ascertained and stored in memory before or during a winding operation in a plurality of measurement motions with defined conditions. This enables both automated and manual detection of the input variables that are required for ascertaining the friction compensation values. This eliminates complicated inputting, which not only minimizes the programming effort and expense but also helps reduce possible mistakes in inputting. Moreover, the system can as a result be adapted quite quickly to different web materials on different winding rollers.

[0024] Another preferred variant method provides that the compensation parameters for the individual process parameters are used for maintenance purposes and/or reports are generated in the event of deviations and/or changes over time compared with specified values. Thus any defects can be reliably detected and displayed, which supports preventive maintenance or even makes it possible in the first place.

[0025] In the methods described above, it may be provided that the process parameter of winding mass is determined as a function of a winding diameter or radius, a winding width, and a density of the material, or in the event of a diameter-dependent variable density of the winding, from a diameter-dependent web tension or a characteristic winding hardness curve. This makes independent determination of the winding mass-dependent compensation possible, even without taking into account the acceleration compensation, in which the mass of the winding is known and is carried along in the process.

[0026] It may also be provided that the process parameter of temperature is determined by measuring the temperature at the winding drive or by calculation using a thermal model. Temperature-dependent friction components can thus be determined exactly and suitably compensated for.

[0027] A variant method provides that the process parameter of roller contact pressure is measured or calculated from further process parameters. This is advantageous particularly if a contact pressure roller is used.

[0028] To compensate for winding layer-dependent components, it may be provided that the compensation parameters that are dependent on the process parameter of actual motor angle or winding angle value are stored in memory in the form of a database inside the friction compensation unit or the control/regulating device, for instance in the form of a table.

[0029] The object in terms of the apparatus is attained in that to compensate for the frictional moment in the friction compensation unit, at least one additional process parameter is imposed. This makes it possible in particular to employ the

variant methods described above for the sake of improved taking into account of the most various friction compensation components.

[0030] In one embodiment, an acceleration compensation unit is located in the control/regulating device, which makes improved regulation possible, especially in the presence of constantly varying web speeds.

[0031] A preferred embodiment provides that the friction compensation unit, as additional input variables, has a winding mass and/or a temperature and/or a roller contact pressure and/or an actual motor angle or winding angle value, as a result of which winding mass-dependent, temperature-dependent, optionally contact pressure roller-dependent, and/or winding layer-dependent components can be taken into account in specifying the driving torque.

[0032] For simple determination of the friction compensation values, the friction compensation unit may have at least one performance graph unit for linking at least two process parameters.

[0033] In an especially preferred variant embodiment, in the friction compensation unit and/or in the control/regulating device, compensation parameters for individual friction components are capable of being determined and are capable of being stored in memory for further evaluations. This makes flexible adaptation to different operating conditions possible on the one hand, and on the other it makes preventive maintenance and checking of the mechanics possible.

[0034] The novel features which are considered as characteristic for the present invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] FIG. 1 is a schematic illustration of a winding machine with a control/regulating device in accordance with the prior art;

[0036] FIG. 2 schematically shows a winding machine with a control/regulating device in a configuration according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0037] FIG. 1 schematically shows an example of a winding machine 1, which as its essential components contains a winding drum 30 that is driven by means of a winding drive 20. A material 70, for instance a weblike product that is to be wound up, is guided in the example shown first over a first deflection device 61, in this case embodied as a fixed roller, and after that over a second deflection device 62, which is embodied as a loose roller, and then over a third deflection device 63, in the form of a further fixed roller, and finally reaches the winding drum 30; in the example shown, a contact pressure roller 40 presses the material 70 onto the already-formed winding on the winding drum 30, for instance to prevent air bubbles.

[0038] The deflection device 62 is in mechanical operative communication with a force measuring device 50. The force measuring device 50, which on one end is fixedly connected to the structure of the winding machine 1, may for instance be embodied as a load cell, with which the tensile stress of the

material 70 during the winding can be determined. The measured values are delivered (this is not shown here) to a control/regulating device 10 (or winding computer) and serve in particular as an input variable for a tensile stress regulator 11 which is integrated with the control/regulating device 10 and controls the winding drive 20. Alternatively, only a setting of the tensile force may be done.

[0039] In the prior art, the control/regulating device 10 includes still other functional elements, such as a diameter calculation unit 12, an acceleration compensation unit 13, and a friction compensation unit 14, which serve to linearize the controlled system for the tensile stress regulator 11, in order to enable performing regulation as independently as possible of interference variables. This leads to improved regulating quality of the entire system. In the process, as shown, a controlling variable, in the form of an output signal of the tensile stress regulator 11, is united with corrective controlling variables to form output signals of the diameter calculation unit 12 and of the acceleration compensation unit 13, to form a controlling variable in a first linking member 15.

[0040] Next, in the example shown, in a second linking member 16, a further corrective controlling variable is delivered as an output signal of the friction compensation unit 14 to the control signal for the winding drive 20. Typically, the friction compensation and the acceleration compensation are imposed as pilot control for the driving torque. The algorithms of the individual components in the control/regulating device 10 are stored in memory by different process variables and control the winding drive 20.

[0041] In the prior art, it is provided that the friction compensation unit 14 is supplied, as its process parameter 80, only with the value for a winding speed 81 of the winding drum 30. The value for a compensation value for the frictional moment is typically calculated from the winding speed 81 in a relatively simple model.

[0042] FIG. 2 schematically shows a winding machine 1 in a configuration according to the invention, which unlike the embodiment shown in FIG. 1 has a control/regulating device 10 in which the friction compensation unit 14 has additional process parameters 80 on the input side.

[0043] Besides being supplied with the winding speed 81 of the winding drum 30, in the example shown the friction compensation unit 14 is also supplied, as an additional input variable, with a value for a winding mass 82, a value for a temperature 83 of the winding drive 20, a value for a roller contact pressure 84, and a value for an actual motor angle or winding angle value 85. As indicated in FIG. 2, still other input variables may be imposed on the friction compensation unit 14 as well.

[0044] In one embodiment, it may be provided that the compensation values for the various friction components are imposed additively, independently of one another. For instance, besides the rpm-dependent friction compensation value, a path with a winding mass-dependent friction compensation value can be added as well. The two paths are independent of one another; that is, the rpm-dependent friction compensation is imposed independently of the winding mass, and the winding mass-dependent friction compensation is imposed independently of the rpm.

[0045] In another embodiment, it is provided that the total drive compensation is formed additively from mutually dependent compensation components. In this, at least two of the dependent variables are linked with one another and the compensation value is ascertained from that. In the model,

this produces characteristic curve graphs or performance graphs, which in the case of two variables dependent on one another can be represented as a surface in space. For instance, the compensation values for friction can be determined from a characteristic curve graph which is plotted from the winding mass **82** and the winding speed **81** of the winding drum **30**.

[0046] As a further dimension of the performance graph, the temperature **83**, the roller contact pressure **84**, and the actual motor angle or winding angle value **85** can be used. The characteristic curve graphs need not be completely known here. For instance, the compensation values can be determined by suitable interpolations (for instance linear interpolation) from the characteristic curve graph, even if only a few of the interpolation points are known.

[0047] The apparatus in FIG. 2, in the friction compensation unit **14** or control/regulating device **10**, therefore according to the invention has at least one performance graph unit **14.1**, which is stored in memory, for instance as software, in the control/regulating program.

[0048] The various friction components can also be determined from a plurality of characteristic curve graphs and then linked together additively. A combination of the evaluation methods described above is also possible.

[0049] It may be provided that the process parameter of winding mass **82** be determined as a function of a winding diameter or radius, a winding width, and a density of the material, or if the density of the winding is variable as a function of diameter, from a diameter-dependent web tension or a winding hardness characteristic curve. Since normally the winding width and the material density are constant in the process, the winding mass **82** is obtained solely as a function of the diameter or the radius. However, the material density can also vary in the process, since because of a specified diameter-dependent web tension (winding hardness characteristic curve), the mean density of the winding can vary. This can also be ascertained, since the web tension or the winding hardness characteristic curve is usually known.

[0050] It can furthermore be provided that the process parameter of temperature **83** is determined by measuring the temperature at the winding drive or by calculation using a thermal model. Temperature-dependent friction components can thus be determined exactly and compensated for accordingly.

[0051] One variant method provides that the process parameter of roller contact pressure **84** is measured or calculated from further process parameters. This is particularly advantageous when a contact pressure roller is used. The corresponding compensation component can be calculated as a function of the contact pressure or optionally further process variables (such as the winding diameter), and that is proportional in a first approximation to the product of the contact pressure and the winding diameter.

[0052] To compensate for winding-layer-dependent components, it is provided that the compensation parameters that are dependent on the process parameter of actual motor angle or winding angle value **85** are stored in memory in the form of a database inside the friction compensation unit or the control/regulating device for instance in the form of a table. One or more gear stages between the motor and the winding drum **30** can be taken into account as well.

[0053] With regard to ascertaining the compensation parameters, which with increasing complexity along with

pure compensation plays an important role, it is provided in terms of the method for instance that automated measurement motions be performed.

[0054] With the measurement motions, the characteristic curve graph can be determined and stored in memory in the controller; for instance, the winding mass-dependent friction compensation can be performed by means of a plurality of measurement motions, for instance with an empty winding, a full winding, and a half-full winding. Each measurement motion can include a plurality of speed measurement points at which the compensation moment is ascertained, for instance from the driving torque present in the winding drive **20**, and the driving torque forming the tensile force must be subtracted from the total driving torque in order to determine the friction compensation.

[0055] Measurement motions for ascertaining the parameters of the temperature-dependent compensation, compensation of the contact pressure roller pressure, and location-dependent compensation can also be performed.

[0056] The measurement motions can also be used for preventive maintenance. For that purpose, measurement motions with an empty winding are advantage, since in that case the properties of the winding material can be ignored. For instance, a limit for the approach frictional moment (break-away torque) or for the maximum frictional moment that occurs, which typically happens at high rpm, beyond which limit a report is generated, can be indicated. This report could for instance be used for repairing or replacing bearings.

[0057] The measurement motions can also be used as reference measurement for checking the mechanics as well. After replacement of mechanical components, such as after a toothed belt change, these components can be checked by means of these measurement motions with respect to the correct setting (for instance, the toothed belt tension) or to the correct function, as well. For instance, if the toothed belt tension is very high, the driving torque will rise equally sharply.

[0058] The variant methods shown and the variant apparatus described make it possible for the various friction compensation components to be taken into account better in the control/regulation of the winding drive **20**, so that markedly improved regulation results. Moreover, the various compensation parameters can be ascertained and monitored largely in automated fashion. The latter can advantageously be used with respect to the maintenance and monitoring of winding machines **1**.

[0059] It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of constructions differing from the type described above.

[0060] While the invention has been illustrated and described as embodied in a method and apparatus for friction compensation, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

[0061] Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

1. A method for friction compensation in a winding machine, comprising the steps of winding a material onto a winding drum; driving the winding drum by a winding drive which is triggered by a control/regulating device; specifying in the control/regulating device a driving torque of the winding drive; taking into account a winding speed of the winding drum in a friction compensation unit, as an input-side process parameter; and taking into account at least one additional input-side process parameter to compensate for a frictional moment.

2. A method as defined in claim 1; and further comprising calibrating a desired tensile force with a measured actual tensile force, by a tensile stress regulator.

3. A method as defined in claim 1; and further comprising affecting a setting of the tensile force by a control part.

4. A method as defined in claim 1; and further comprising specifying in the control/regulating device a driving torque of the winding drive with a unit selected from the group consisting of a diameter calculation unit, the friction compensation unit, and both.

5. A method as defined in claim 1; and further comprising specifying the driving torque of the winding drive in the control/regulating device with an acceleration compensation unit.

6. A method as defined in claim 1; and further comprising, for compensation for the frictional moment, using as the additional input-side process parameter a parameter selected from the group consisting of a winding mass, a temperature, a roller contact pressure, an actual motor angle value, a winding angle value, and combinations thereof.

7. A method as defined in claim 1; and further comprising evaluating the process parameters used for compensation for the frictional moment, independently of one another and additively linked to a total drive compensation.

8. A method as defined in claim 1; and further comprising using the process parameters to compensate for the frictional moment such that at least two of the process parameters are linked to one another; and from that ascertaining a compensation value.

9. A method as defined in claim 1; and further comprising preparing compensation parameters for the process parameters for determining the group consisting of curved graphs and performance graphs; and ascertaining the compensation value for the frictional moment from the performance graphs in a manner selected from the group consisting of directly and by interpolation between interpolation points.

10. A method as defined in claim 1; and further comprising ascertaining compensation parameters from the process parameters; and storing them in memory before or during a winding operation in a plurality of measurement motions with defined conditions.

11. A method as defined in claim 1; and further comprising using compensation parameters for the process parameters for purposes selected from the group consisting of maintenance purposes, generation of reports in an event of deviation, changes over time compared with specified values, and combinations thereof.

12. A method as defined in claim 6; and further comprising parameter selected from the group consisting of a friction a winding diameter, a winding width, and a density of a material, or in an event of a diameter-dependent variable density of the winding, from a parameter selected from the group consisting of a diameter-dependent web tension and a characteristic winding hardness curve.

13. A method as defined in claim 6; and further comprising determining the process parameter of the temperature by a step selected from the group consisting of measuring a temperature at the winding drive and a calculation using a thermal model.

14. A method as defined in claim 6; and further comprising determining a process parameter of the roller contact pressure by a step selected from the group consisting of measuring the process parameter of the roller contact pressure or calculating the process parameter of the roller contact pressure from further process parameters.

15. A method as defined in claim 6; and further comprising storing compensation parameters that are dependent on the process parameters of the actual motor angle or winding angle value in memory in form of a database inside a device selected from the group consisting of the friction compensation unit, the control/regulating device, and both.

16. An apparatus for friction compensation in a winding machine, with which a material is windable on a winding drum and the winding drum is driven by a winding drive triggerable by a control/regulating device, comprising a tensile stress regulator and a unit selected from the group consisting of a diameter calculation unit, a friction compensation unit, and both for linearizing the tensile stress regulator and provided in said control/regulating device; means for imposing in the friction compensation unit a winding speed of the winding drum as an input-side process parameter; and means for imposing at least one additional process parameter to compensate for a frictional moment in the friction compensation unit.

17. An apparatus as defined in claim 16; and further comprising an acceleration compensation unit located in said control/regulating device.

18. An apparatus as defined in claim 16, wherein said friction compensation unit is configured so that as additional input variables it has a parameter selected from the group consisting of a winding mass, a temperature, a roller contact pressure, an actual motor angle value, a winding angle value, and combinations thereof.

19. An apparatus as defined in claim 16, wherein said friction compensation unit is configured so that it has at least one performance graph unit for linking at least two process parameters.

20. An apparatus as defined in claim 16, wherein a device selected from the group consisting of said friction compensation unit, said control/regulating device, and both is configured so that compensation parameters for individual friction parameters are determinable and storable in memory for further evaluations.

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